Water, steam and change: the roles of land drainage, water supplies and garden fountains in the early development of the steam engine

Lissa Roberts

The history of the steam engine is generally linked to that of the Industrial Revolution. This article seeks to uncouple this seemingly necessary link by examining other contexts in which the steam engine was introduced and developed.

Locke sank into a swoon;
The Garden died;
God took the spinning-jenny
Out of his side.
W.B. Yeats, *The Tower* (1928)

We once believed that the industrial revolution was fathered by the scientific revolution. The family resemblance between 'the mechanization of the world picture' and the mechanization of production seems striking. And, even though Yeats portrayed the spinning jenny as the industrial revolution's technological womb, most people have ascribed that function to the steam engine. Much work has been done in recent years to loosen our understanding of technological development from the grip of scientific priority. Less has been done to write histories of apparatus, such as the steam engine, that do not imply an inexorable link to industrialization. The whiggish specter of progress still hangs over our understanding of technological development, particularly for symbols of the industrial revolution such as the steam engine.

The best way around this problem is to return to the historical context(s) in which machines such as the steam engine were introduced. Investigating the economic, political and cultural dynamics of the time helps us to assess the hows and whys of technological invention and development. Far from diminishing our appreciation for the magnitude of technological change, this approach increases our wonder for technology's historical drama by reminding us that the trajectory it has followed was neither necessary nor due to some innate superiority. As is true for any human endeavor, the history of technology is a complex story driven, not by some internal logic, but by several interrelated factors – some technical in nature but most to do with the human drama in which technology is introduced and applied.

We can see this by going back to the steam engine's earliest context of development, described by Hero of Alexandria between the first and second century BC. Hero did not set out in his *Treatise on Pneumatics*[1] to sketch the context in which the steam engine was introduced but, as we read the list of devices that he described, we become aware of more than the inventiveness of Hero and his contemporaries. Many of these contrivances were housed in temples, hinting at the links between the state, religion and technology that then existed. They included steam-powered mechanisms for opening temple doors, pouring libations over alters and making godlike figures move and make noises (Figure 1).

Historians have examined Hero's machines as precedents for inventions produced in the wake of his book's translation during the Renaissance. However, it is also profitable to examine them in terms of the needs and desires of their own cultural context. What kind of environment, we might ask, called for harnessing novel technology to produce religious wonders?

Hero's treatise was first published in Italian in 1547 followed by a Latin translation in 1575, which was reprinted and distributed in both Paris and Amsterdam, making the book relatively accessible. Whether or not it was used as a blueprint for invention, steam technology had not completely died out in the intervening centuries. However, beginning with figures such as Giambattista della Porta, Salomon de Caus and Cornelis Drebbel in the early 17th century, steam engines slowly began appearing across Europe's technological landscape.

Lissa Roberts

Is currently on leave from her position as Associate Professor of History at San Diego State University. She has written extensively on the history of chemistry and the role of instruments in the development of science. With a grant from the US National Science Foundation, she is completing a book on the cultural history of Dutch science and technology in the 18th century, with a special focus on the introduction of the steam engine.
jbspaa@xs4all.nl

0160-9327/00/$ – see front matter PII: S0160-9327(00)01240-5

It was not long before attempts were made to harness steam power to pump water out of coal mines, but this was not the only locus of the steam engine's application and development (Figure 2). Because of the contextual conditions in Europe, at least three other uses were crucial to the steam engine's development and diffusion through the 18th century – steam was also put to work in gardens to power decorative fountains, in land drainage and for water supply. After a few words about the use of steam engines in coal mines, the rest of this article focuses on these other, less-publicized areas of application.

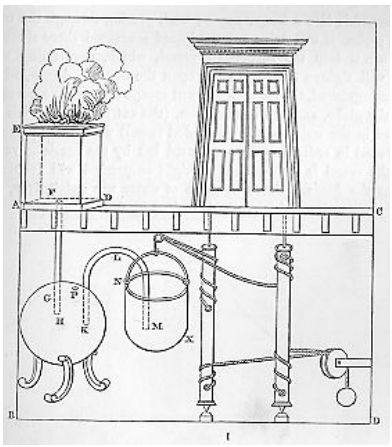

Figure 1 A small temple designed by Hero of Alexandria. When the fire is lit on the altar, the hot air expands into the underground reservoir and displaces the liquid within it via a siphon into a counterbalanced container suspended by chains attached to the door mechanism. The weight of the liquid makes the suspended container descend and pulls on the chains attached to the base of the pivoted temple doors and they swing open. When the fire goes out, the air cools and contracts, the liquid siphons out of the suspended container, which rises and shuts the doors.

Working in a coal mine

To help explain why England and Belgium industrialized earlier than other parts of Europe, commentators have singled out their large coal deposits and the use of steam technology to exploit them. However, if the spread of steam technology was not dependent on coal mining, neither did the desire to exploit coal deposits always translate into the installation of steam engines. The historian of technology S. Lindqvist analyses a case in point[2]. He explains technology transfer as a cultural process in which a novel technology encompasses more than its brute mechanism; it simultaneously embodies the values of its culture of origin. To be successfully assimilated into a foreign environment, both its mechanical and its cultural features must be modified appropriately.

In Sweden, for example, steam engines had to withstand the physical conditions of the Dannemora Mines but they also had to contend with local views on the scarcity of resources and energy consumption. Economic backing had to be found, in terms of both immediate financing and, theoretically, long-term cost effectiveness. Steam engines were notorious for breaking down, which threatened the local social order in two ways that had to be compensated for: firstly, when they did not work, neither did the workers, who consequently did not get paid; secondly, foreign technicians were often brought in to oversee the maintenance of these unfamiliar machines, which threatened the local technicians' sense of job security and status.

Finally, the steam engine arrived in Sweden with the cultural baggage of English utilitarianism and natural theology. Rhetoric about the 'public good' and God's creative glory had little meaning in the traditional cultural setting of a Swedish mining community. Not until the late 18th century was a more appropriate fit between Swedish culture and that represented by the steam engine recognized.

Matthew Boulton told Samuel Boswell that he and James Watt sold what everyone in the world wanted – power

Machines in the garden

It might seem strange to say that the steam engine's introduction depended even partially on cultural values but this reasoning becomes clearer when we look at other sites where steam engines were installed. Particularly during a time when technological schemes in most of Europe still depended largely on royal and aristocratic patronage for their financing, we can expect the values and interests of that class to be reflected in the projects that were brought to fruition with their support.

M.N. Wise has traced a telling (if late) example in his examination of the introduction of steam engines in 19th century Prussia[3]. As he explains, steam engines were erected in the royal gardens of Berlin at a time when Prussia was beginning to compete industrially with Great Britain. The engines were not to clear mines or to run factories but to power decorative fountains. The Prussians harnessed them to symbolize royal power as a vehicle of imperial progress, whereby industrialization was wedded to centrally controlled social and aesthetic programs.

The Berlin engines were perhaps the last in a long line of garden installations. Della Porta, De Caus and Drebbel all designed steam-powered fountains for wealthy patrons. De Caus, for example, erected steam-driven fountains for Prince Henry of England (the son of James I) and the Elector Palatine Frederick V. In 1717, the Newtonian lecturer and experimental demonstrator John Theophilus Desaguliers designed a steam pump to power fountains in St Petersburg for Czar Peter I. Five years later, the Prince of Schwarzenburg engaged the Austrian Royal Architect Joseph Emmanuel Fischer Von Erlach to build steam-powered fountains for his garden in Vienna. Later in the 18th century, the English engineer William Blakey installed six steam-driven fountains around Paris, including one for the Prince de Condé.

Leo Marx entitled his classic study of technology's place in the American literary imagination *The Machine in the Garden*[4] but no one has yet examined the significance of these real 'machines in the garden'. Instead, they are usually (if at all) mentioned in terms of their influence on engines that served more 'useful' purposes in mines, manufacturing or water supply. This perspective diminishes the role of aristocratic patrons and other non-capitalists in the history of technological development. It also obscures the meanings with which machines such as the steam engine were imbued by those who sponsored their construction and witnessed them at work.

France

Matthew Boulton told Samuel Boswell that he and James Watt sold what everyone in the world wanted – power. However, royal and aristocratic patrons during the *Ancien Régime* had rather different relations to power than did industrial entrepreneurs. Recent histories of garden architecture show that the reigning aesthetics in royal and noble parks were often carefully planned projections of their owners' claim to wield power. The sociologist C. Mukerji analyses the potent symbolism projected by such gardens and the role of innovative technology (although not the steam engine in this case) in making that projection both possible and successful[5]. As she argues, the control over nature wrought by engineering prowess and advances in plant cultivation was shaped at Versailles to advertise Louis XIV's power before domestic and foreign guests. His gardens, for example, reflected an alliance between the engineering brilliance of French fortifications and the delicate laces manufactured under the regime of French mercantilist monopolies. Everywhere one looked – the vistas were carefully constructed to emphasize the message of regal pre-eminence – Louis's power was clear to see.

England

The marriage between garden design and technological development was furthered by other kings and aristocratic patrons throughout Europe in the 18th century; specific results reflecting the position and aims of the patrons involved. Thus, English garden design (and the technologies it put to work) sought to express a more natural sensibility, in conscious reaction to the formalism and tyranny of French gardens. The ideal of the new English landscape style was to erase, as much as possible, the boundary between an estate's sculpted grounds and the countryside that surrounded it. This ideal was paradoxical in three ways. First, it called on the application of technology to recreate nature. Second, landscape gardens were cheaper to maintain than formal gardens and lent themselves more effectively to agricultural exploitation. Third, as the art historian A. Bermingham points out, the landscape parks of noble estates evoked the ideals of wild freedom and spaciousness at the very time when the island's upper classes were subjecting increasing areas of the English countryside to enclosure[6].

The Netherlands – an Arcadian apparatus

Uses of steam power in the Netherlands did not mimic the trends supported by royal and aristocratic patronage in either France or England. The first operating steam engine built there powered a water-management project on the outskirts of Rotterdam in 1776. The second, designed by the Amsterdam merchant Rinze Lieve Brouwer and built wholly from domestically produced parts, was erected in 1781 in the park of a wealthy banker's estate. Unlike other garden installations, this engine did not propel jets of water from classically sculpted fountains. Rather, it regulated the level and flow of water throughout the park. In keeping with the Dutch variant of the trend to naturalize garden design in the late 18th century, Brouwer's steam engine helped to control the environment, just as the Dutch had been doing for centuries as part of their national struggle to dominate the landscape in order to survive and prosper. The Netherlands had long been portrayed in art and literature as a garden. Now, an individual garden reflected the Netherlands' national character by teaming steam technology with an architectural sensibility of aesthetic naturalism.

Given the Dutch preoccupation with water management, it is not surprising that this was the context in which steam engines were introduced in the Netherlands. Most steam engines built there during the 18th and early 19th centuries were used for land drainage and water management. A trading nation with abundant supplies of peat and almost no coal, the Dutch looked at technology such as steam engines with different eyes to those of their neighbors. If the Dutch did not conspicuously consume or patronize after the manner of Versailles, neither did they invest domestically in the sort of productive enterprises that transformed 19th-century England into a landscape punctuated by soot-belching factories.

The Dutch sought to maintain their pastoral landscape even as they tried to reverse their economic downturn in the 18th and 19th centuries. It was as if the Arcadian ideal of the Dutch countryside nourished its champions as they sought to recapture the glory of their nation's golden age in the 17th century. An active core of Dutch reformers thought that the steam engine could help this drive and pushed to supplement the windmills that stood sentry throughout the land with pumps powered by steam.

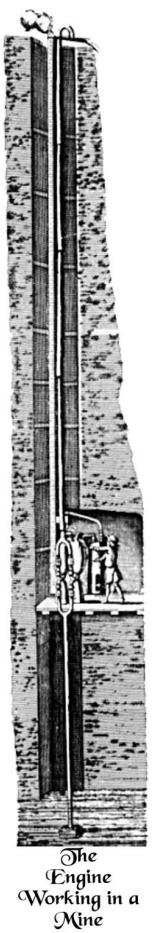

Figure 2 Savery's engine.

Urban engines

Although the Netherlands was the most urbanized society in Europe, its urban centers were no match for 18th-century London or Paris in size, population or the material challenges that accompanied city life on such a large scale. Inhabitants of both of these cities struggled to obtain basic services, which gave rise to countless schemes, including projects to supply water to urban dwellers. As early as 1712, the York Buildings Company sought to satisfy London's need for water by pumping it from the Thames with steam-powered machinery. In France, the Périer brothers were granted a licence in 1778 to supply Paris with water pumped by steam from the Seine. The two projects were separated by time, geography and culture but shared interesting characteristics. Both were financed through the formation of a company (the Périers gathered a 'war chest' of 3,500,000 French Francs for their project) and both relied on influential patrons to help to insure government approbation.

London

As the historian of science L. Stewart explains, the York Buildings Company was a quintessential English joint-stock company, including being basically shady thanks to the gallery of participants who lined their pockets on its account[7]. Pumping water from the Thames was not the company's only project but its directors saw it as potentially lucrative enough to finance other schemes whose respectability and profitability were more questionable. The road to success was paved by pursuing two strategies. First, the highly regarded experimental philosopher Desaguliers was engaged in the 1720s to help to oversee technical aspects of the project. Desaguliers brought a level of expertise and lent the patina of scientific respectability to the endeavor through his reputation as an arbiter of scientific and social utility. Intellectual and cultural capital proved to be as crucial to the project's success as financial capital.

Simultaneously, a campaign to outwit rivals and to win governmental sponsors was spearheaded by the company's leading member, the Duke of Chandos, a man who spent most of his adult life pursuing entrepreneurial schemes. He and his associates accomplished their mission after a harrowing series of intrigues, scandals, technical hurdles and financial challenges. The Newcomen engine, proposed to replace a long-out-of-commission Savery pump in 1724, began operating in 1726. Despite public outcries against the rain of soot caused by the engine's enormous appetite for fuel, the system worked – at least, until 1731, when company directors decided that they could no longer afford to feed what had come to be labeled the 'York Buildings dragon'. After years of greasing the wheels of patronage and public prejudice, they cut their losses and replaced their much heralded steam engine with horse power.

Paris

The project launched five decades later by Jacques Constantin and Augustin Charles Périer involves a similar story, in that they operated in an environment that also demanded investments of financial, intellectual and cultural capital. They had to find backers who could provide funds as well as help to garner ministerial favor, without which approval for the project would never have been granted. Building steam engines for clients such as the Duke of Orleans helped pave their way. On the Duke's estate, they constructed a Savery-type pulsometer that powered a system for filling a reservoir, which was tapped for household use and for watering the expansive gardens; heat from the boiler was also used to warm the house[8].

The question of intellectual capital actually highlights more differences than similarities between the English and the French. Both Desaguliers and the Duke of Chandos were associated with the Royal Society, which conferred on them public recognition as amateurs of science, but Desaguliers still had to work for a living. He earned his money and reputation by demonstrating for the Society, public lecturing, consulting on scientific and engineering projects, and, through the patronage of the Duke of Chandos, as a churchman.

It was different for Jacques Constantin Périer. As a member of the French Royal Academy of Sciences, he had a guaranteed income as well as status. He had access to knowledge through contact with fellow academicians and with French patent seekers, who presented their work to the Academy for review. As a public servant (both under Louis XVI and during the French Revolution), he sat on review committees and advisory boards for government projects; he even taught at the Ecole Révolutionnaire des Armes et Poudres. However, the relative financial independence and social status afforded by his membership in the Academy freed him to pursue projects such as the Seine River scheme under his own name, even if he still depended on the intervention of supportive patrons to reach the ears of government ministers.

Conclusion

The Périers finally got their license and began pumping water from the Seine with steam in 1778. At about the same time, James Watt and Matthew Boulton began marketing engines of a very different design from those discussed here. Their technical prowess and business acumen are part of a story that redirected the steam engine's identity from an innovative but undependable technology to a motor of the industrial age. To appreciate the power this transformation helped to unleash, we need to appreciate the complexities of the history in which the steam engine was previously involved.

If we think of technology transfer as a process by which innovations are adapted to the conditions of new locales, so should we think about the history of technology as the adaptive transfer of innovations through time. Success depends on technical factors but, more importantly, requires the establishment of a snug yet dynamic fit between a technology and its environment in economic, political and cultural terms. For the steam engine to develop successfully, its design needed to be retooled for mechanical amelioration and greater efficiency. However, it also had to be made to satisfy the value-driven urges of the various contexts in which it was introduced.

References

1 Hero (1851) *Treatise on Pneumatics* (Woodcroft, B.E., ed. and translator), Taylor, Walton and Maberly. Also posted at http://www.history.rochester.edu/steam

2 Lindqvist, S. (1984) *Technology on Trial: The Introduction of Steam Power Technology into Sweden 1715–1736*, Almqvist and Wiksell International

3 Wise, M.N. *Architectures for Steam*, posted at http://www.princeton.edu/~hos/

4 Marx, L. (1964) *The Machine in the Garden: Technology and the Pastoral Ideal in America*, Oxford University Press

5 Mukerji, C. (1999) *Territorial Ambition and the Gardens of Versailles*, Cambridge University Press

6 Bermingham, A. (1987) *Landscape and Ideology: The English Rustic Tradition 1740–1860*, Thames and Hudson

7 Stewart, L. (1992) *The Rise of Public Science: Rhetoric, Technology and Natural Philosophy in Newtonian Britain 1660–1750*, Cambridge University Press

8 Payen, J. (1969) *Capital et Machine à Vapeur au XVIII Siècle: Les Frères Périer et l'introduction en France de la Machine à Vapeur de Watt*, Mouton